

EIG.

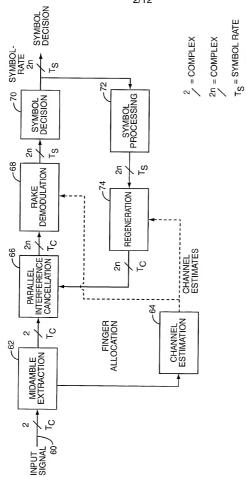


FIG. 2

T_C = CHIP RATE

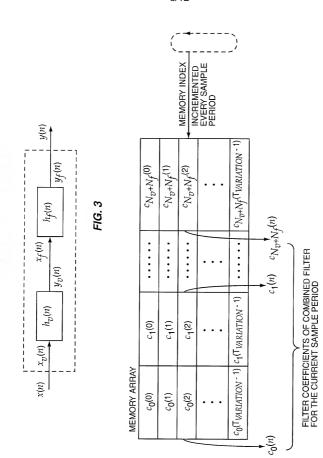
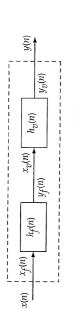


FIG. 4



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FIG. 5

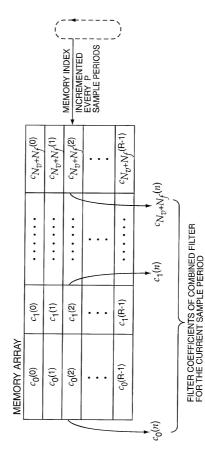
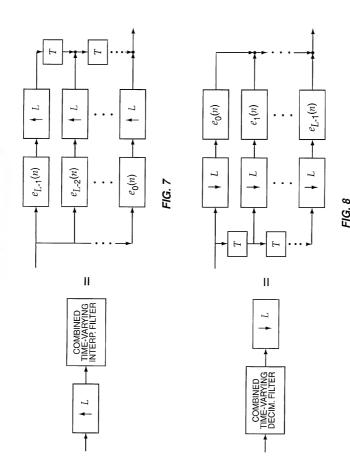


FIG. 6



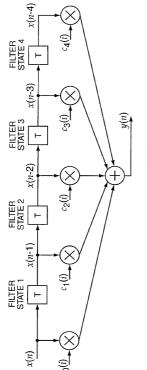


FIG. 9

| | | i | /- - | | | |
|--------------------|----------------------------|-------------------------------------|--|---|---|---|
| | | | | INCREMENTED EVERY SAMPLE | MEMOBY INDEX | יוויין ווייין וויין ווייין וויין ווייין וויייין ווייין ווייין ווייין ווייין ווייין וויייין וויייין וויייין ווייין וויייין וויייין וויייין ווייייין ווייייין וויייין וויייין וויייייייי |
| c ₄ (0) | c ₄ (1) | c ₄ (2) | c ₄ (3) | c ₄ (4) | c ₄ (5) | |
| (3(0) | c ₃ (1) | c ₃ (2) | (2) ⁽³⁾ | c ₃ (4) | c ₃ (5) | |
| c ₂ (0) | $c_2(1)$ | $c_2(2)$ | c ₂ (3) | c ₂ (4) | c ₂ (5) | |
| $c_1(0)$ | $c_1(1)$ | $c_1(2)$ | $c_1(3)$ | c ₁ (4) | c ₁ (5) | |
| (0) ⁰ 2 | c ₀ (1) | c ₀ (2) | c ⁰ (3) | c ₀ (4) | $c_0(5)$ | |
| | $c_1(0)$ $c_2(0)$ $c_3(0)$ | $c_1(0)$ $c_2(0)$ $c_3(0)$ $c_3(1)$ | $c_1(0)$ $c_2(0)$ $c_3(0)$ $c_4(0)$ $c_1(1)$ $c_2(1)$ $c_2(1)$ $c_3(1)$ $c_4(1)$ $c_1(2)$ $c_2(2)$ $c_3(2)$ $c_4(2)$ | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ | $\begin{array}{c ccccccccccccccccccccccccccccccccccc$ |

FIG. 10

EXAMPLE FILTER OUTPUTS FOR FOURTH-ORDER COMBINED FILTER

| $\begin{array}{cccccccccccccccccccccccccccccccccccc$ | IIME NDEX | $ \begin{array}{c c} \Gamma \text{IME} & \text{INPUT} \\ NDEX & x(n) \\ n \end{array} $ | FILTER STATE 1 x(n-1) | FILTER STATE 2 x(n-2) | FILTER FILTER FILTER MEMORY STATE 1 STATE 2 STATE 3 STATE 4 INDEX $x(n-1)$ $x(n-2)$ $x(n-3)$ $x(n-4)$ i | FILTER STATE 4 x(n-4) | MEMORY INDEX i | OUTPUT $y(n)$ |
|---|--------------|---|-----------------------------|-----------------------------|---|-----------------------------|----------------------|---|
| G F F C B C C B C C C C C C C C C C C C C | | 4 | 0 | 0 | 0 | 0 | 0 | $A \cdot c_0(0) + 0 \cdot c_1(0) + 0 \cdot c_2(0) + 0 \cdot \ c_3(0) + 0 \cdot c_4(0)$ |
| C B A O O C B B A C O C C B C C C C C C C C C C C C C C C | | В | A | 0 | 0 | 0 | - | $B \cdot c_0(1) + A \cdot c_1(1) + 0 \cdot c_2(1) + 0 \cdot \ c_3(1) + 0 \cdot c_4(1)$ |
| C C B C B C C C C C C C C C C C C C C C | | ပ | В | ⋖ | 0 | 0 | 2 | $\mathtt{C} \cdot c_0(2) + \mathtt{B} \cdot c_1(2) + \mathtt{A} \cdot c_2(2) + \mathtt{0} \cdot \ c_3(2) + \mathtt{0} \cdot c_4(2)$ |
| G E D C B A A B C C B C C B C C C C C C C C C | | D | ပ | В | A | 0 | 3 | $D \cdot c_0(3) + C \cdot c_1(3) + B \cdot c_2(3) + A \cdot \ c_3(3) + 0 \cdot c_4(3)$ |
| G F C B 5 | | ш | О | O | В | 4 | 4 | $E \cdot c_0(4) + D \cdot c_1(4) + C \cdot c_2(4) + B \cdot \ c_3(4) + A \cdot c_4(4)$ |
| G F E D C C C C C C C C C C C C C C C C C C | | ш | ш | Q | ပ | , в | 5 | $F \cdot c_0(5) + E \cdot c_1(5) + D \cdot c_2(5) + C \cdot \ c_3(5) + B \cdot c_4(5)$ |
| G F E D 1 | | σ | ш | ш | ٥ | O | 0 | $G \cdot c_0(0) + F \cdot c_1(0) + E \cdot c_2(0) + D \cdot \ c_3(0) + C \cdot c_4(0)$ |
| | | Ξ | 5 | ш | ш | О | - | $H \cdot c_0(1) + G \cdot c_1(1) + F \cdot c_2(1) + E \cdot c_3(1) + D \cdot c_4(1)$ |

FIG. 1

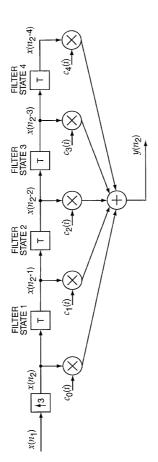


FIG. 12

EXAMPLE FILTER OUTPUTS FOR FOURTH-ORDER INTERPOLATION FILTER

| о ит рит <i>y(n</i> 2) |
|--|
| |
| $A \cdot c_0(0) + 0 \cdot c_1(0) + 0 \cdot c_2(0) + 0 \cdot \ c_3(0) + 0 \cdot c_4(0)$ |
| $\begin{array}{c} A \cdot c_0(0) + 0 \cdot c_1(0) + 0 \cdot c_2(0) + 0 \cdot c_3(0) + 0 \cdot c_4(0) \\ \\ 0 \cdot c_0(1) + A \cdot c_1(1) + 0 \cdot c_2(1) + 0 \cdot c_3(1) + 0 \cdot c_4(1) \end{array}$ |
| $c_1(0) + 0 \cdot c_2$ |
| $\begin{array}{c} (1) + 0 \cdot c_1(0) \\ (1) + A \cdot c_1(1) \\ (2) + 0 \cdot c_1(2) \end{array}$ |
| $\begin{array}{c} A \cdot c_0(0) + 0 \cdot c_1(0) + 0 \cdot c_2(0) + 0 \cdot c_3(0) + 0 \cdot c_4(0) \\ \\ 0 \cdot c_0(1) + A \cdot c_1(1) + 0 \cdot c_2(1) + 0 \cdot c_3(1) + 0 \cdot c_4(1) \\ \\ 0 \cdot c_0(2) + 0 \cdot c_1(2) + A \cdot c_2(2) + 0 \cdot c_3(2) + 0 \cdot c_4(2) \\ \end{array}$ |
| 0 + |
| 0 |
| |
| $x(n_2^{-1}) \mid x(n_2^{-2}) \mid x(n_2^{-3}) \mid x(n_2^{-4})$ |
| STATE 1 STATE 2 STATE 3 STATE 4 $x(n_2-1)$ $x(n_2-2)$ $x(n_2-3)$ $x(n_2-4)$ |
| INPUT FILTER FILTER FILTER FILTER MEMORY $x(n_2)$ STATE 1 STATE 2 STATE 3 STATE 4 INDEX $x(n_2^{-1})$ $x(n_2^{-2})$ $x(n_2^{-3})$ $x(n_2^{-4})$ i |
| TIME INPUT $n_2 = x(n_1)$ |
| TIME ⁿ 2 |

FIG. 13

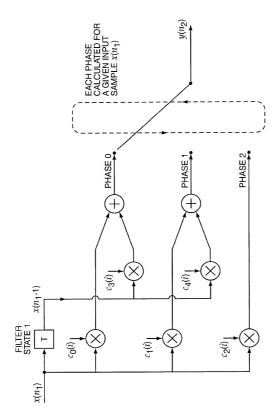


FIG. 14

EXAMPLE FILTER OUTPUTS FOR FOURTH-ORDER POLYPHASE INTERPOLATION FILTER

| | 6 | (| | 3) | () | | (0 | 1) | |
|---------------------------------|-----------------------------------|-----------------------------------|------------------------|---|---|---------------------------|-----------------------------------|-----------------------------------|------------------------|
| OUTPUT $y(n_2)$ | $A \cdot c_0(0) + 0 \cdot c_3(0)$ | $A \cdot c_1(1) + 0 \cdot c_4(1)$ | A • c ₂ (2) | $\mathbf{B} \cdot c_0(3) + \mathbf{A} \cdot c_3(3)$ | $\mathbf{B} \cdot c_1(4) + \mathbf{A} \cdot c_4(4)$ | $\mathbf{B} \cdot c_2(5)$ | $C \cdot c_0(0) + B \cdot c_3(0)$ | $C \cdot c_1(1) + B \cdot c_4(1)$ | C · C ₂ (2) |
| MEMORY INDEX i | 0 | 1 | 2 | 3 | 4 | 5 | 0 | 1 | 2 |
| SELECTED PHASE | 0 | + | 2 | 0 | - | 2 | 0 | 1 | 2 |
| FILTER STATE 1 $x(n_1-1)$ | 0 | 0 | 0 | ٧ | A | ٨ | В | В | В |
| x(n ₁) | ۷ | ı | ı | В | I | ı | O | - | _ |
| TIME ⁿ 2 | 0 | - | 2 | 3 | 4 | 5 | 9 | 7 | 8 |

FIG. 18

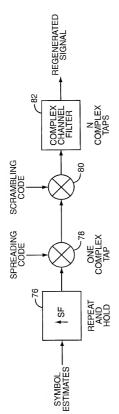


FIG. 16 PRIOR ART

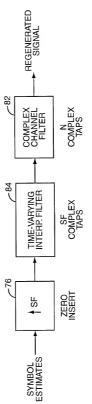


FIG. 17 PRIOR ART